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1 340 068

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(54) THE LINING OF SURFACES DEFINING PASSAGEWAYS

(71) We, INSITUFORM (PIPES & STRUCTURES) LTD., a British Company of Lloyds Bank Chambers, Vicar Lane, Yorkshire, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the lining of surfaces which define passageways. By the expression "passageways" as used herein and in the appended claims is meant pipe the bores of pipes, which may or may not be located underground, or underground tunnels or shafts such as sewers or mine shafts.

Frequently such surfaces,become or are unsuitable for their intended purpose. For example, a newly formed pipe length for carrying fluid or other medium may have a small fracture or hole, or the inner surface may be imperfectly formed so as to be unsuitable for the intended purpose or in the case of an existing pipe length, the inner surface may have become unsuitable simply as a result of wear and tear through usage. Again, with underground passageways, such as sewers and mine shafts, the walls defining such passageways may deteriorate as a result of use, so that such surfaces allow the undesirable leakage therethrough into the passageway of fluid such as water from the outside of the passageway, or the leakage therethrough from the inside of the passageway of the fluid being carried by the passageway. Also, in the case where an underground passageway carries a fluid medium such as sewage, erosion of the surface defining the passageway by the flow of the fluid can make the surface rough and irregular, causing difficulties with the flow of the fluid.

When such a difficulty has arisen in the past, the only course considered available before the present invention, was the replacement of the pipe length or whole pipe, in the case of pipelines, or the formation of a new underground passageway, in the case of an underground passageway.

The present invention deals with the lining of such surfaces defining passageways, whereby instead of a pipe length being rejected and replaced or instead of a new underground passageway being formed or constructed, the surface can be lined thereby restoring same for further use. Moreover, the invention can

also be applied as a precautionary measure where the surface to be lined is not in actual fact faulty, but it is believed may become faulty in the near future. Again, the invention may be employed where the use of a passageway changes, such that the existing surface is unsuitable for the new use, and also the invention may be applied simply to reinforce or support a surface defining a passageway.

According to the present invention, a method of lining a surface at least partially defining a passageway comprises urging against said surface by fluid pressure, a flexible laminate comprising a membrance which is relatively impermeable to fluids and a fibrous sheet structure which is impregnated with an uncured synthetic resin with the fibrous sheet structure lying between the surface and membrane, so that the laminate takes up the shape of such surface, and curing or causing to cure said resin whilst the laminate is in such shape whereby a lining for such surface is formed.

By the expression "relatively impermeable to fluids" is meant, as applied to membranes and materials herein, is meant that the membrane or material is sufficiently imperforate to enable it to be inflated and/or shaped by fluid under pressure and held by fluid under pressure in such condition, consistant with the present invention, to enable the fibrous sheet structure to be set by a curing of the resin in the shaped condition.

Preferably, the laminate is in tubular form and comprises an inner tube of said material which is relatively impermeable to fluids around which is disposed said fibrous sheet structure, and the tubular laminate is inflated so as to be urged against and into the shape of said surface.

Preferably, also there is an outer tube of material which is relatively impervious to fluids surrounding said fibrous sheet structure.

The fibrous sheet structure preferably includes a mat or web or randomly orientated fibres which may be of glass and/or synthetic fibres The fibres in the mat may be of differing denier

It has been found that a mat or web of randomly orientated fibres is very suitable for soaking up resin when impregnated so that a wetted out web or mat absorbs the maximum amount of resin.

We prefer to use a needled felt of synthetic plastics material fibres, which may or may not include filamentary reinforcement

The fibrous sheet structure may include a second sheet in the form of a woven scrim.

The fibrous mat or web is preferably wrapped round the inner tube and the meeting edges thereof may be butted together or overlapped; in either case, the edges are preferably joined together so that there is no creation of a line of weakness in the tube when it is inflated.

In some cases, it may be required that only a part of a passageway requires to be lined for example, to patch a fracture in a surface or to line a section where the surface has become rough and irregular, or to line only the bottom half of a sewer in which the sewage flows. The invention extends to this requirement although in such cases it would not be necessary to have the laminate in tubular form, but it could be in sheet form and may comprise the fibrous sheet structure sandwiched between two membranes of a material which is relatively impermeable to fluids. In such case the laminate would be positioned to cover the desired area and shaped accordingly by fluid pressure.

The invention also resides in a flexible laminate for lining passages comprising a tubular membrane of a material which is relatively impermeable to fluids and around which is a layer of needled, fibrous felt which is impregnated with uncured synthetic resin.

The invention further resides in a passageway surface lined according to the method as aforesaid.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings which are not to scale and wherein.

Fig. 1 is a diagrammatic perspective view of an apparatus for producing a tubular laminate for the lining of surfaces defining passageways;

Fig. 2 is a cross sectional view of the tubular laminate in flattened condition;

Fig. 3 is a cross sectional view of the tubular laminate when in inflated condition in a passageway to be lined;

Fig. 4 is a perspective cut away view of a laminate in sheet form for the lining of surfaces defining passageways;

Fig 5 is a perspective view showing how such sheet laminate is used to line the bottom of a sewer so that the sewage will run in the lining; and

Fig. 6 is a sectional elevation showing how a pipe may be provided with a tubular lining.

Referring now to the drawings in detail, and firstly to Figure 1, in this figure there is shown, diagrammatically only, an apparatus for producing a laminate in tubular form for lining pipes or underground passageways.

The apparatus comprises basically a stand 10 which carries a roll of fibrous sheet in the form of a needled felt 12 and such felt is fed in web form from the roll 12 as formation of the tubular laminate proceeds.

Adjacent the stand 10 is a further roll

stand 14 which carries in roll form a flattened tube of a material which is relatively impermeable to fluids, in this case a synthetic plastics material. In this case the material which is indicated by numeral 16 is polythene, and the tube may be formed in any convenient manner for example by extrusion or by folding and seam welding. In the formation of the tubular laminate, the polythene tube 16 passes over the web of felt as the two are unrolled and the tube 16 and felt 12 are fed together past a needling apparatus which is indicated generally by numeral 18. In passing from the stand 10 to the needling apparatus 18 the web 12 which is more than twice the width of the tube 16 is folded over to wrap round the tube as indicated and so that the meeting edges of the felt 12 overlap as shown. These overlapping edges are needled together by the needle pad 20 of needling apparatus 18 so that a tube of felt surrounding the tube of polythene 16 is formed. Instead of needling, these edges may be connected together by adhesive or welding or they may be left unconnected. Thus formed composite tube passes between a pair of feed rollers 22 each carrying a roll of synthetic plastics film material again of polythene and each of such rolls has a width greater than the width of the composite tube passing therebetween. The sheets of film lying respectively above and below the flattened composite tube are fed from the rolls 22 as movement of the composite tube progresses in the direction of arrow 24 (fig. 1) and also the overlapping edge regions of the sheets which are fed from rolls 22 are sealed together by heat sealing heads 23 so that in effect there is produced a tubular laminate of the form shown in figure 2. It should be noted that this figure is not to scale and the respective layers of the laminate have been shown as distinctly separate in the interests of clarity. In actual fact whilst the layers are not at this time in any way anchored together they will nevertheless lie in close contact with another. The tubular laminate comprises the inner tube 16 of polythene, the intermediate tube 12 of needled felt and the outer tube 26 of polythene constituted by the respective sheets fed from roller 22 which are heat sealed along edges 28 as indicated in figure 2. In an alternative method of forming the tube the inner tube is inflated by fluid pressure whilst the firbrous sheet structure is wrapped round the inflated tube.

In order to line say the surface defining an underground sewer, the tubular laminate as indicated in figure 2 is first of all treated so as to impregnate the felt 12 with uncured synthetic resin. This can be done in any suitable manner and one method we have found to be suitable is to puncture the outer tube 26 and insert by pumping or injection the uncured resin. Another method is to inject the resin by long tubes extending lengthwise of the tube and between the inner and outer tubes. The resin is absorbed quickly by the felt 12 and if absorpsion does not take place evenly then the distribution of the resin throughout the felt can be improved by passing the flattened tube through the nip of a pair of nip rollers.

Whilst the resin remains uncured the tubular laminate is still flexible and in order to line a sewer with the tubular laminate as indicated in figure 3 it is simply a matter of entering the laminate into the sewer and then inflating same for example with air under pressure from a fan or blower so that the laminate takes up the shape of the sewer wall as shown in figure 3, the tube being closed at its ends to enable inflation to take place or inflated by means of an inflatable bag positioned in the tube. With the tube so inflated, the uncured resin is either allowed to cure naturally or is cured under the action of heat depending upon which type of resin is used. By inflating the tube, the tube is pressed outwardly against the sewer wall indicated by the arrows in figure 3.

Figure 6 shows how the tubular laminate may be used for the lining of a pipe 30.

To line a complete sewer or pipe line it may be necessary to use a number of tubular laminates which are overlapped and/or joined end to end but the technique of using fluid pressure to urge each laminate against the surface to be lined is followed in each case.

The inner tube 16 may be of a material which is or becomes firmly bonded to the resin carried by felt 12 or alternatively after the curing of the resin it may be capable of removal from the cured resin depending upon the materials used for the tube 16 and the resin which is used.

Moreover, in some cases it may be possible to dispense with the outer tube 26 in which case the felt impregnated with resin would be applied directly to the surface to be lined.

Once curing of the resin is complete the formed liner simply remains in position in the pipe line or in the sewer and additional anchoring devices may be used if desired.

Because the tubular laminate has to be inflated to take up the final shape lining a sewer or pipe line it is preferred that the materials which are used for the tubular laminate be somewhat elastic and capable of some extension in order to obviate the need for accurate dimensioning of the tubular laminate in relation to the passageway which is to line

In some cases, it may be that only part of the passageway need be lined rendering the use of the tubular form of laminate unnecessary In such case a laminate for

example as illustrated in Figure 4 may be used. This laminate comprises a felt inner layer 32 which is of the same material as the felt 12 and this is sandwiched between two plastic material sheets 34, 36 which are sealed together at overlapping edges 38 so as in effect to form a tubular casing for the felt 32. Again, the felt is impregnated with uncured synthetic resin before being used and Figure 5 shows an example of a sewer in which the bottom of the sewer is lined by a sheet laminate such as is illustrated in Figure 4. The laminate is laid over the bottom of the sewer and then it is urged to take up the shape of the bottom of the sewer by the passage over the laminate of a fluid which may be the sewage itself or some other liquid such as water. In any case, the hydrostatic pressure resulting from the weight of the liquid forces the laminate down into the well 40 of the sewer as shown in Figure 5 effectively lining the bottom of the sewer, and the resin is cured or allowed to cure.

Where the uncured resin is applied to the felt by puncturing the synthetic plastics material covering the felt is is preferred that any such puncture be covered by means of a patch which may be of a self adhesive nature and may be applied simply by an operator.

It is to be appreciated, in the method that a number of possible materials may be used instead of or in combination with the needled felt, the requirement being that there should be a fibrous sheet structure which is impregnated with uncured resin prior to the shaping of the laminate to the surface to be lined. Such fibrous sheet structure may also be reinforced by filamentary or other materials and it may include a scrim web to which the felt web is attached for example by needling to give the fibrous sheet structure stability and strength. The sheet structure may be a woven or knitted sheet and it may include or be composed of a glass fibre mat or rovings.

In the preferred case, we utilise a needled felt of synthetic fibres such as polyester, nylon or acrylic fibres. Polyester fibres are preferred because they have the highest degree of chemical resistance. The fibres in any needled felt may included of fibres of differing denier.

In some cases so called "bright" fibres or clear fibres are used for the needled web and these are impregnated with a clear resin to give a transparent liner.

The resin which is used cures hard and is preferably a low exotherm resin. i.e a resin which releases little heat as it cures or is cured, and if a resin which releases substantial heat whilst curing is used then care should be taken to select a material for the inner and outer tubes 16 and 26 and layers 34 and 36 (in the case of a sheet laminate) which will withstand the heat generated during the curing. We use mainly polyester resin although epoxy resin can also be used. Polyester resin has the advantage that it cures naturally and by the use of a catalyst the curing time can be varied. With a polyester resin having a cobalt accelerator we have used a catalyst cyclohexanolperoxide. The resin may contain any one or more additives, such as fillers, colourants fire retardants as desired.

The material which is used for the inner tube 16, the outer tube 26 and the outer layers 34 and 36 as previously described may be any suitable synthetic plastics or other material and examples of such materials are polythene, polyvinylchloride, butyl, rubber, cellophane (Registered Trade Mark) nitrate, neoprene and polyester film. Where a tubular laminate is formed it is preferred that the inner tube be formed of a material which is of relatively high impermeability to fluids so that the laminate can be shaped with fluid pressure and there will be no leakage through the liner; normally the outer tube of the laminate will be of the same material although this is not essential as the requirement for impermeability in the outer tube is not normally as high as in the inner tube because the fluid pressure as will normally be applied directly to the inner tube to form the tubular laminate to the passageway to be lined. The materials of the outer and inner tube can of course be different as desired.

The impregnation of the fibrous sheet structure in the laminate may be carried out during the formation of the laminate instead of by injection as described herein but in such case it will be necessary to use the laminate before the resin cures or otherwise it will not be possible to form the laminate to the desired shape of the passage.

We feel that the advantages of this invention are fairly clear insofar as by this invention it is possible to line the surface of a passageway such as a sewer with a synthetic resin which cures hard and forms an effective liner for the passage such as will in many cases render the repair or replacement of the passage unecessary. The same comment also applies to pipes which may or may not be located underground. Instead, therefore, of a damaged or old pipe being replaced it may simply be lined according to the method of the invention and this will in many cases render the pipe as serviceable as it was when new.

Moreover, the lining does not need to be over the entire surface of the passage; sections or areas of the passageway can be lined for example as illustrated in Figure 5 as desired. To achieve the lining of only part of the surface defining the passageway it may be necessary to pressurise the whole

passageway and this would be done by blanking off the ends of the length of the passageway containing the part of the surface required to be lined. The sheet laminate may require initially to be positioned before the pressurisation of the passage, but when pressurised the existing pressure would press the laminate to the surface and form it to such surface.

WHAT WE CLAIM IS:—

1. A method of lining a surface at least partially defining a passageway comprising urging against said surface by fluid pressure, a flexible laminate comprising a membrane which is relatively impermeable to fluids and a fibrous sheet structure which is impregnated with an uncured synthetic resin with the fibrous sheet structure lying between the surface and membrane, so that the laminate takes up the shape of such surface, and curing or causing to cure said resin whilst the laminate is in such shape whereby a lining for such surface is formed.

2. The method according to claim 1, wherein the laminate is in tubular form and comprises an inner tube of said material which is relatively impermeable to fluids around which is disposed said fibrous sheet structure, and the tubular laminate is inflated so as to be urged against and into the shape of said surface.

3. The method according to claim 2, wherein there is an outer tube of material which is relatively impervious to fluids surrounding said fibrous sheet structure.

4. The method according to claim 2 or 3, wherein the said outer and/or inner tube are/is of synthetic plastics material.

5. The method according to claim 2, 3 or 4 wherein the fibrous sheet structure is a mat or web which is wrapped round the inner tube.

6. The method according to claim 5, wherein the meeting edges of the fibrous sheet structure are overlapped and joined together.

7. The method according to claim 1, wherein the laminate is in sheet form and comprises the fibrous sheet structure sandwiched between two membranes of a material which is relatively impermeable to fluids.

8. The method according to any of claims 2 to 7 wherein the fibrous sheet structure includes a mat or web of randomly orientated fibres.

9. The method according to claim 8, wherein the fibrous sheet structure is a needled web.

10. The method according to claim 9, wherein the fibres of the needled web are polyester fibres.

11. A method according to any preceding claim, wherein the resin is a polyester resin.

12. A method according to any preceding claim, wherein the said material which is relatively impermeable to fluids is polythene.

13. A method according to any preceding claim, wherein the surface lined is that of an underground sewer.

14. A method according to any of claims 1 to 13, wherein the surface lined is the inner surface of a pipe.

15. A method according to any preceding claim wherein the laminate is urged against and shaped to said surface by air under pressure.

16. A method of lining a surface defining a passageway substantially as hereinbefore described.

17. A passageway having at least part of its surface lined according to the method of any one of the preceding claims.

18. A flexible laminate for lining a surface defining a passageway comprising a tubular membrane of a material which is relatively impermeable to fluids and around which is a layer of needled, fibrous felt which is impregnated with uncured synthetic resin.

19. A flexible laminate according to claim 18, wherein the fibrous felt is of polyester fibres.

20. A flexible laminate according to claim 18 or 19, wherein the fibrous felt is a web wrapped round the tubular membrane and the meeting edges are overlapped.

21. A flexible laminate according to claim 20, wherein the overlapped edges are needled together.

22. A flexible laminate according to any of claims 18 to 21, including an outer tube of a material which is relatively impermeable to fluids and which surrounds the fibrous felt.

23. A flexible tube according to any of claims 18 to 22, wherein the resin is polyester resin.

24. A flexible laminate according to any of claims 18 to 23, wherein said inner tube is of polythene.

25. A flexible laminate substantially as hereinbefore described with reference to figs 2, 3 and 6 of the accompanying drawings.

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1340068 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

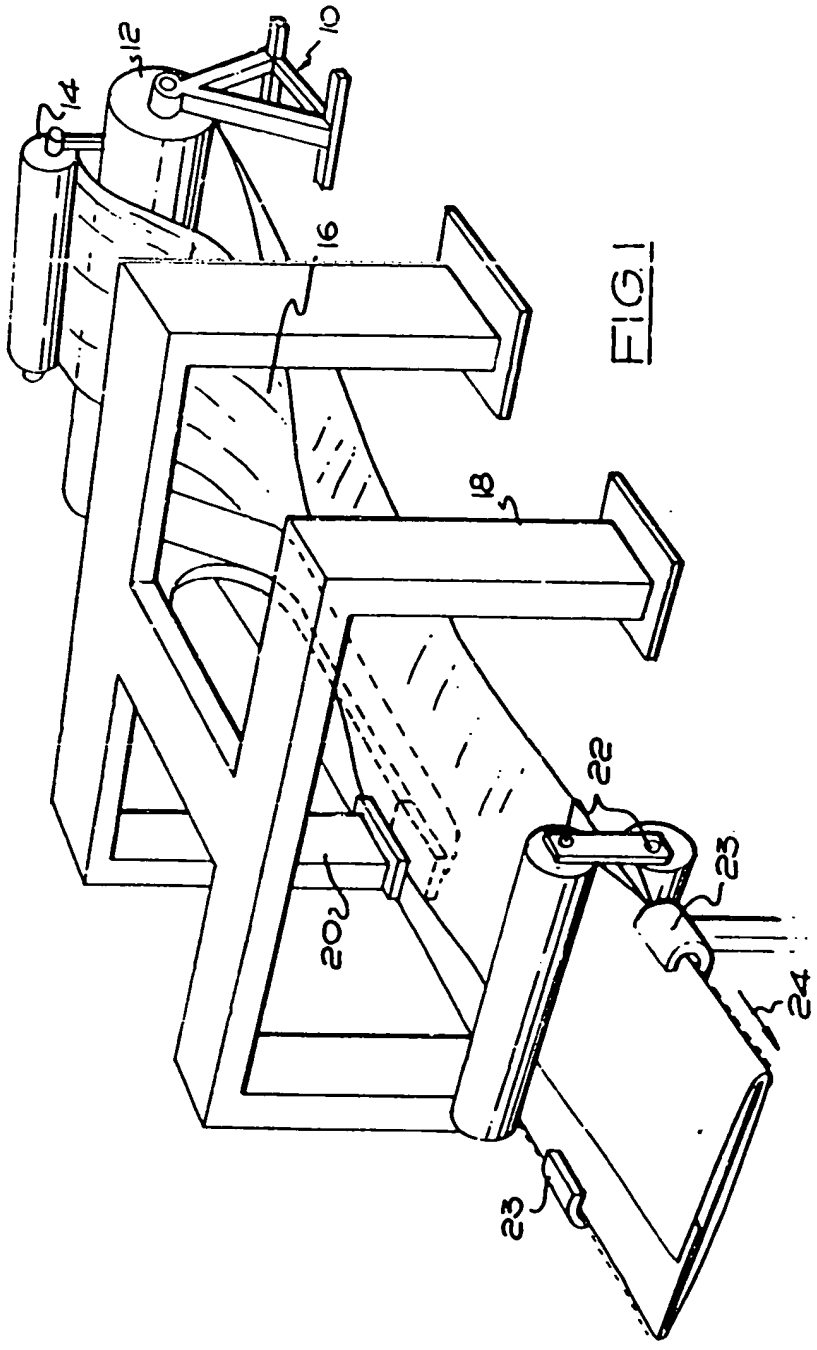

FIG.1

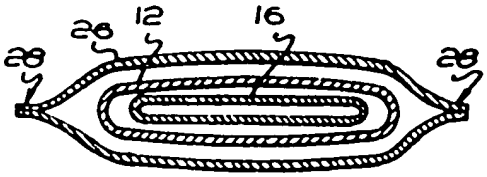

FIG. 2

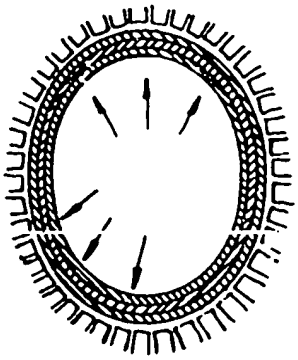

FIG. 3

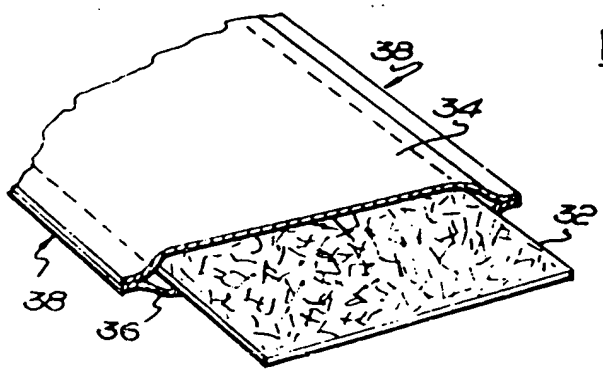

FIG. 4

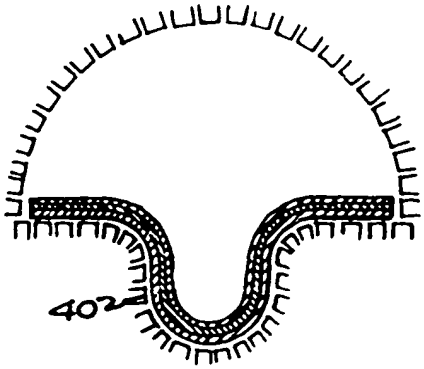

FIG. 5

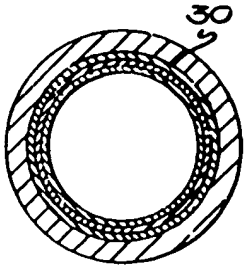

FIG. 6